

This listing of claims will replace all prior versions, and listings, of claims in the application:

Listing of Claims:

Claim 1 (previously amended): A joint control apparatus for controlling the movement of a robot joint, which includes a first link and a second link where the first link is rotated about a predetermined axis with torque generated by the apparatus, said apparatus comprising:

an actuator;

electric current detection means included in said actuator for detecting a drive current of the actuator;

torque detection means included in said actuator for detecting the amount of torque based on the drive current detected by said electric detection means; and

control means included in said actuator for controlling the actuator based on the amount of torque detected by said torque detection means.

Claim 2 (canceled)

Claim 3 (original): The joint control apparatus according to Claim 1, wherein the actuator includes:

a motor unit that generates the torque depending on a supplied drive current;

a torque amplification unit that amplifies the torque generated by said motor unit, and transmits the torque to the actuator; and

motor control means included in said motor unit for controlling said motor unit by supplying said motor unit with a level of drive current based on externally provided control information.

Claim 4 (previously amended): A joint control method for controlling the movement of a robot joint in which the joint includes a first link and a second link where the first link is rotated about a predetermined axis with torque generated by the apparatus, said method including:

 a first step of detecting a drive current of the actuator using an electric current detection means included in the actuator;

 a second step of detecting an amount of torque based on the drive current detected by the electric current detection means using torque detection means included in the actuator; and

 a third step of controlling the actuator using control means based on the amount of torque detected in said second step.

Claim 5 (canceled)

Claim 6 (previously amended): A robot device including a joint control apparatus for controlling the movement of the joint, which includes a first link and a second link where the first link is rotated about a predetermined axis with torque generated by the apparatus, said apparatus comprising:

 an actuator;

 electric current detection means included in said actuator for detecting a drive current of the actuator;

 torque detection means included in said actuator for detecting the amount of torque based on the drive current detected by said electric current detection means; and

 control means included in said actuator for controlling the actuator based on the amount of torque detected by said torque detection means.

Claim 7 (canceled)

Claim 8 (original): The robot device according to Claim 6, wherein the actuator includes:

 a motor unit that generates the torque depending on a supplied drive current;
 a torque amplification unit that amplifies the torque generated by said motor unit, and transmits the torque to the actuator; and
 motor control means included in said motor unit for controlling said motor unit by supplying said motor unit with a level of drive current based on externally provided control information.

Claim 9 (previously amended): A robot device control method having a joint mechanism for controlling the movement of a the joint, which includes a first component and a second component where the first component is rotated about a predetermined axis with torque that is output from the actuator through an output axis of the actuator, comprising:

 a first step of detecting an electric current value of the drive current of the actuator using electric current detection means included in the actuator;
 a second step of detecting a level of a torque created by an external force applied to the output axis of the actuator based on the detected electric current value using control means included in said actuator; and
 a third step of controlling the actuator using control means included in said actuator such that the torque created by the external force applied to the output axis of the actuator can be removed based on a detected result obtained in said second step.

Claim 10 (canceled)

Claim 11 (original): A robot device having a pair of leg units in each of which a lower leg unit is connected to a thigh unit through a knee joint mechanism, and a foot unit connected to the lower leg unit through an ankle joint mechanism, said pair of leg units being driven in a predetermined pattern such that a walking operation is performed wherein said foot units of said leg units alternately touch a walking path on which the robot device is placed said robot device comprising:

an actuator, provided in said ankle joint mechanism, generating a rotation torque whose level depends on a drive current for rotation-driving said foot unit on a predetermined axis;

electric current detection means included in said actuator for detecting an electric current value of the drive current of the actuator;

torque detection means included in said actuator for detecting a level of torque created by an external force applied to the output axis of the actuator based on the electric current value detected by said electric current detection means; and

control means included in said actuator for controlling the actuator based on a detection result from said torque detection means such that the external force applied to the output axis of the actuator can be removed.

Claim 12 (original): The robot device according to Claim 11, said actuator comprising:

a motor unit generating the rotation torque depending on a supplied drive current;

a torque amplification unit amplifying the rotation torque generated by said motor unit, and transmitting the torque to said output axis; and

motor control means included in said motor unit for controlling said motor unit by supplying said motor unit with the drive current at a level according to externally provided control information.

Claim 13 (original): A method of controlling a robot device having a pair of leg units in which a lower leg unit is connected to a thigh unit through a knee joint mechanism, and a foot unit is connected to the lower leg unit through an ankle joint mechanism, said pair of leg units being driven in a predetermined pattern such that a walking operation is performed wherein said foot units of said leg units alternately touch a walking path one which the robot device is placed, said method comprising:

a first step of detecting an electric current value of the drive current using electric current detection means included in an actuator in said ankle joint mechanism, and generating a rotation torque whose level depends on a drive current for rotation-driving said foot unit on a predetermined axis;

a second step of detecting an externally applied torque using external torque detection means included in said actuator, where said external torque is determined by creating an external force applied to the output axis of the actuator based on the detected electric current value; and

a third step of controlling the actuator using control means included in said actuator, based on a detection result obtained in said second step, such that the external force applied to the output axis of the actuator can be counteracted.

Claim 14 (original): A joint device in which a first link connected to a second link is freely rotatable about a predetermined axis, the joint device comprising

an actuator generating rotation torque for rotation-driving said first link about said predetermined axis,

said actuator comprising:

~~a motor unit generating the rotation torque; and~~

motor control means included in said motor unit for controlling the rotation torque output from said motor unit.

Claim 15 (original): The joint device according to Claim 14, further comprising:

torque amplification means for amplifying the rotation torque output from said motor unit, characterized in that

said motor unit and said torque amplification means are incorporated into one unit.

Claim 16 (original): A robot device having a joint mechanism in which a first component is connected to a second component in a freely rotating manner about on a predetermined axis, and

an actuator generating a rotation torque for rotation-driving said first component about the predetermined axis, said actuator comprising:

a motor unit generating the rotation torque; and

motor control means included in said motor unit for controlling the rotation torque output from said motor unit.

Claim 17 (original): The robot device according to Claim 16, further comprising

a torque amplification means for amplifying the rotation torque output from said motor unit, characterized in that

said motor unit and said torque amplification means are incorporated into one unit.

Claim 18 (previously added): A control apparatus for controlling a joint mechanism comprising:

a first link;

a second link connected to said first link being capable of rotating around a predetermined axis;

a motor for rotating said first link around said predetermined axis on the basis of a rotation-torque output through an output axis of the motor; and

control means for controlling said joint mechanism;

wherein

 said motor has a motor case that includes a rotation axis, drive means for driving said rotation axis, electric current detection means for detecting an electric current value of the drive current of the motor, and external force torque detection means for detecting a torque applied to the output axis of the motor based on the electric current value detected by the electric current detection means in said motor case, and wherein

 said control means controls said joint mechanism based on said external force torque detected by said external force torque detection means.

Claim 19 (previously added): A robot apparatus including a joint mechanism comprising:

a first link;

a second link connected to said first link being capable of rotating around a predetermined axis;

a motor for rotating said first link around said predetermined axis on the basis of a rotation torque output through an output axis of the motor; and

control means for controlling said joint mechanism;

wherein

 said motor has a motor case that includes a rotation axis, drive means for driving said rotation axis, electric current detection means for detecting an electric current value of the drive current of the motor, and external force torque detection means for detecting a torque applied to the output axis of the motor based on the electric current value detected by the electric current detection means in said motor case, and wherein

 said control means controls said joint mechanism based on said external force torque detected by said external force torque detection means.

Claim 20 (previously added): A robot apparatus having a plurality of joint mechanisms driven by an actuator comprising:

 a memory for storing a plurality of values of self weight (tare) torque which are applied to each joint at the time of each posture;

 means for calculating an output torque which drives each of said joints;

 means for calculating an external force torque applied to said joint by subtracting said self-weight (tare) torque from said output torque; and

 control means for controlling said joint mechanism according to said external force torque.

Claim 21 (previously added): The robot apparatus of Claim 20, wherein said actuator includes:
electric current detection means for detecting an electric current value of the drive current of the actuator; and
external force torque detection means for detecting a level of torque by an external force applied to the output axis of the actuator based on the electric current value detected by said electric current detection means.

Claim 22 (previously added): A robot apparatus including a joint mechanism comprising:
a first link;
a second link connected to said first link being capable of rotating around a predetermined axis;
a motor for rotating said first link around said predetermined axis on the basis of a rotation torque output through an output axis of the motor; and
control means for controlling said joint mechanism; and wherein:
said motor has a motor case that includes servo control means for controlling the motor rotation by a servo system; and
said control means controls said joint mechanism based on said servo control by said servo control means.

Claim 23 (new): A robot apparatus having a joint unit, comprising:
a joint control unit for controlling the joint unit; and
a motor unit provided in said joint unit and including motor control means, electric current detection means for detecting an electric current value of a motor drive electric current, and operation processing means, wherein:
said operation processing means, which is inside said motor unit, calculates an external force torque generated at said joint unit based on said electric current value; and
said joint control means controls said motor control means so as to reduce said external force torque.

Claim 24 (new): The robot apparatus according to claim 23, wherein the robot apparatus is a legged walking robot and said joint unit is an ankle joint unit.

Claim 25 (new): A control method for a robot apparatus having a joint unit and a motor unit for driving said joint unit, comprising:

— a first step at which, inside said motor unit including motor control means, electric current detection means for detecting an electric current value of a motor drive electric current, and operation processing means, said operation processing means calculates an external force torque generated at said joint unit based on said electric current value; and

— a second step at which joint control means provided outside said motor unit controls said motor control means so as to reduce said external force torque.

Claim 26 (new): The control method for a robot apparatus according to claim 25, wherein the robot apparatus is a legged walking robot and said joint unit is an ankle joint unit.

Claim 27 (new): A robot apparatus having a joint unit, comprising:

— a motor unit provided in said joint unit, and including motor control means, electric current detection means for detecting an electric current value of a motor drive electric current, and operation processing means, wherein:

— said operation processing means, inside said motor unit, calculates an external force torque generated at said joint unit based on said electric current value and said motor control means controls said motor unit so as to reduce said external force torque.

Claim 28 (new): The robot apparatus according to claim 27, wherein the robot apparatus is a legged walking robot and said joint unit is an ankle joint unit.

Claim 29 (new): A control method for a robot apparatus having a joint unit and a motor unit for driving said joint unit, comprising:

a first step at which, inside said motor unit including motor control means, electric current detection means for detecting an electric current value of a motor drive electric current, and operation processing means, said operation processing means calculates an external force torque generated at said joint unit based on said electric current value; and

a second step at which said motor control means controls said motor unit so as to reduce said external force torque calculated.

Claim 30 (new): The control method for a robot apparatus according to claim 7, wherein said robot apparatus is a legged walking robot and said joint unit is a joint unit of an ankle.